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Ljung

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(54) **APPARATUS AND METHODS FOR ANONYMOUS PAIRED DEVICE DISCOVERY IN WIRELESS COMMUNICATIONS SYSTEMS**

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H04W 48/16 (2009.01)
H04W 12/02 (2009.01)

(52) **U.S. Cl.**

CPC ***H04W 48/16*** (2013.01); *H04W 12/02* (2013.01)

(58) **Field of Classification Search**

CPC . H04W 72/085; H04W 76/023; H04W 48/12; H04L 2209/805; H04L 27/2626; H04L 5/0007; H04L 5/0044
USPC 370/254, 328, 329
See application file for complete search history.

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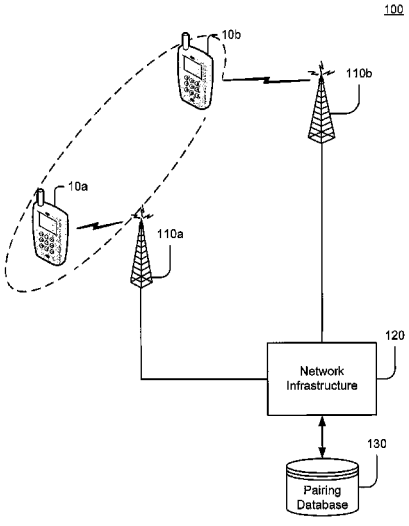
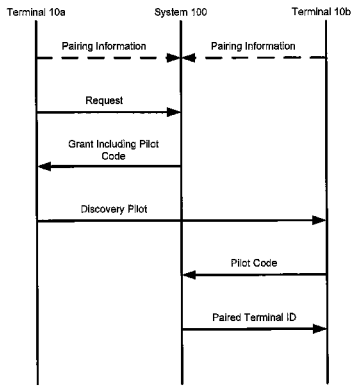
(57) **ABSTRACT**

A wireless communications system transmits a first message including an anonymous discovery pilot identification code to a first terminal, receives a second message from a second terminal and determines whether the second message identifies the discovery pilot identification code. The system may transmit a third message identifying the first terminal to the second terminal responsive to the second message identifying the discovery pilot identification code. Transmission of the first message may be preceded by receiving a request message from the first terminal requesting permission to transmit a discovery pilot signal.

5 Claims, 3 Drawing Sheets





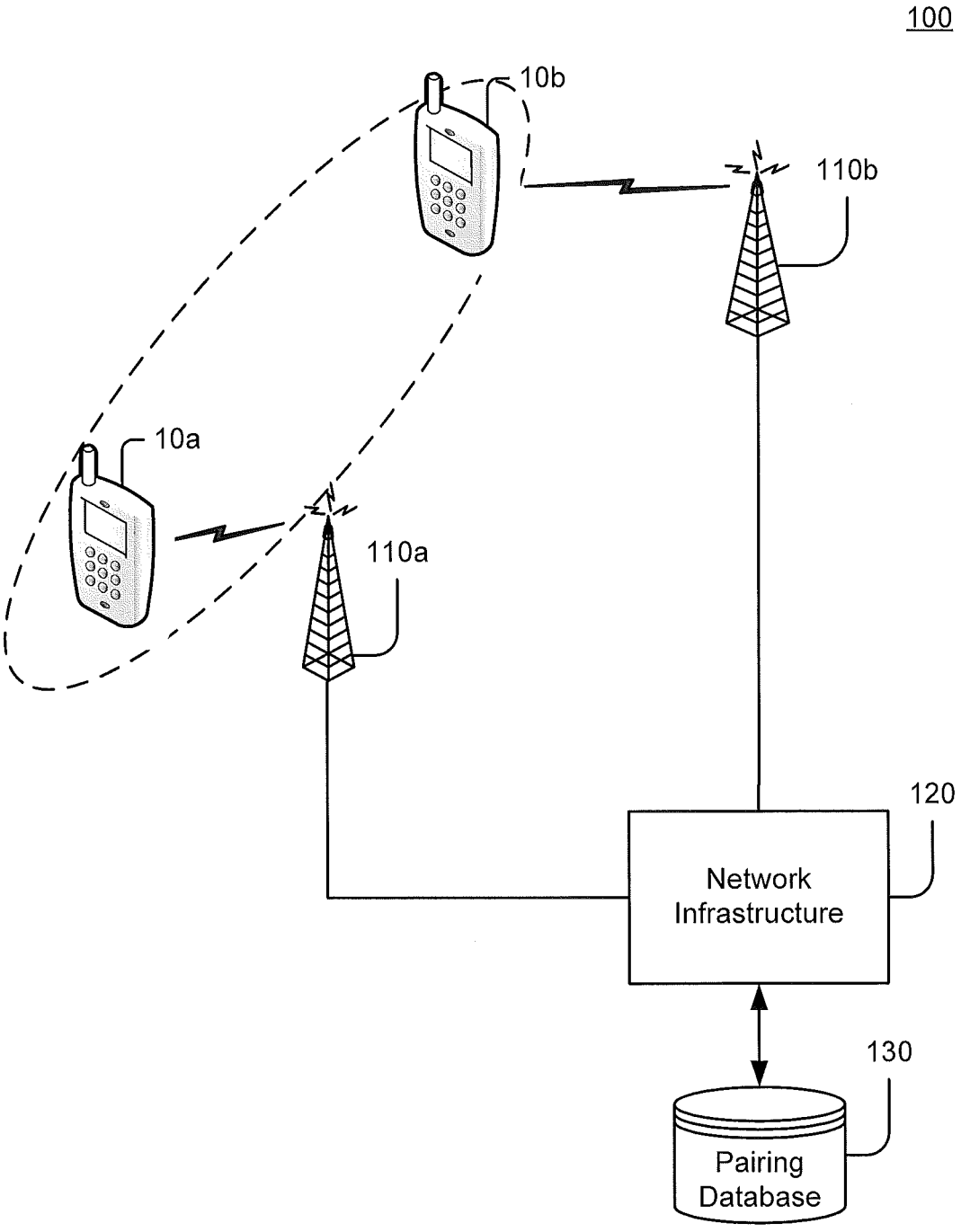

100
10b
110b
10a
110a
120
Network Infrastructure
130
Pairing Database

FIGURE 1

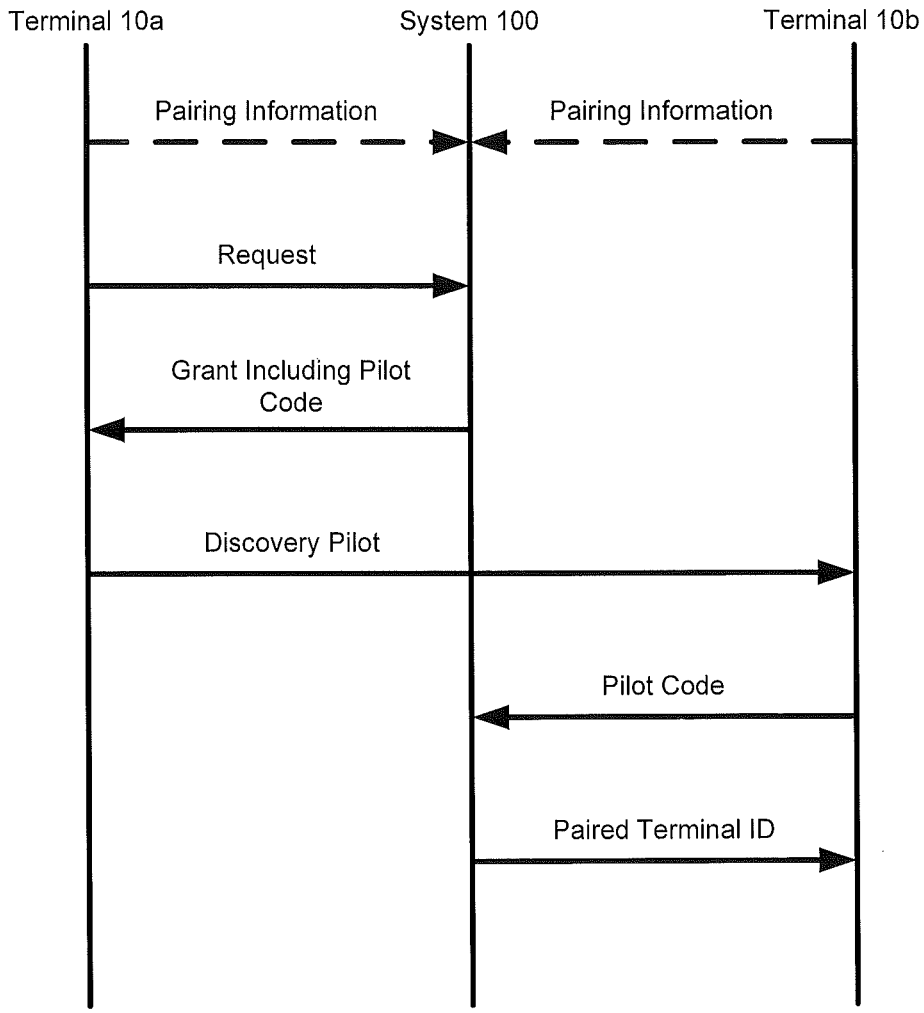

Terminal 10a
System 100
Terminal 10b
Pairing Information
Pairing Information
Request
Grant Including Pilot Code
Discovery Pilot
Pilot Code
Paired Terminal ID

FIGURE 2

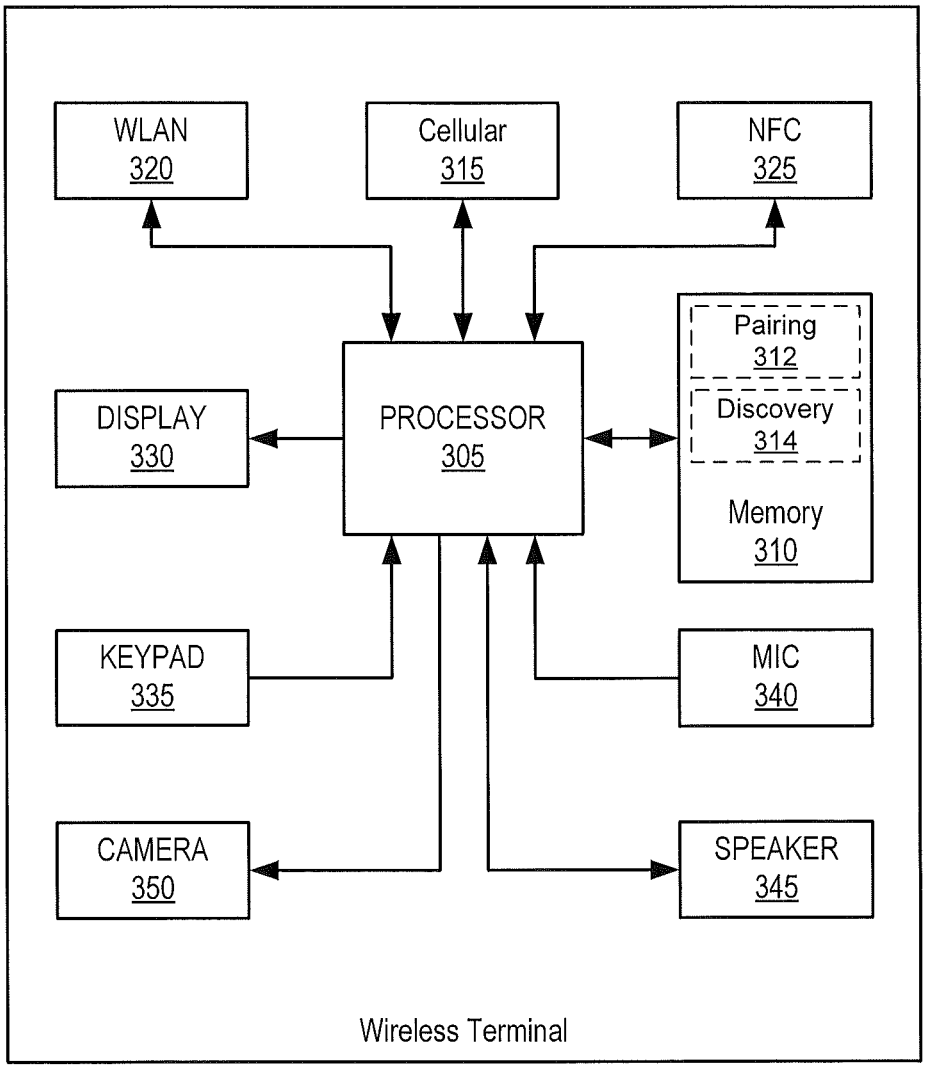

WLAN
320
Cellular
315
NFC
325
Pairing
312
DISPLAY
330
PROCESSOR
305
Discovery
314
Memory
310
KEYPAD
335
MIC
340
CAMERA
350
SPEAKER
345
Wireless Terminal

FIGURE 3

APPARATUS AND METHODS FOR ANONYMOUS PAIRED DEVICE DISCOVERY IN WIRELESS COMMUNICATIONS SYSTEMS

BACKGROUND OF THE INVENTION

The inventive subject matter relates to wireless communications and, more particularly to device discovery in wireless communications.

A mobile terminal in a wireless mobile network typically only communicates with one or more network base stations. However, it is often useful to have knowledge about other mobile terminals that currently are located in relatively close proximity. For example, such information may be of use for local remote controlling or finding friends in the neighborhood (e.g., for gaming, localized commercials, automatic alarm system control, etc.).

In order to discover devices being within the same area, one can utilize Internet-based so-called "over the top" services. Such approaches may involve a terminal using its GPS receiver to find its position and transmitting the position coordinates to a server located on the Internet. The server may identify other devices that are within a certain proximity to the terminal. However devices to be found may need to use the same non-standardized system for discovery, and there may be integrity and security issues with transmitting position information to a central database.

SUMMARY

Some embodiments of the inventive subject matter provide methods of operating a wireless communications system. The methods include transmitting a first message including an anonymous discovery pilot identification code to a first terminal, receiving a second message from a second terminal and determining whether the second message identifies the discovery pilot identification code. The methods may further include transmitting a third message identifying the first terminal to the second terminal responsive to the second message identifying the discovery pilot identification code. Transmission of the first message may be preceded by receiving a request message from the first terminal requesting permission to transmit a discovery pilot signal.

In some embodiments, transmission of the first message may be preceded by receiving at least one message identifying a relationship between the first and second terminals. Receiving at least one message identifying a relationship between the first and second terminals may include receiving respective messages from the first and second terminals.

In some embodiments, transmission of the third message may be preceded by searching a database responsive to the second message identifying the discovery pilot identification code to determine whether the second terminal is paired with the first terminal, and wherein transmission of the third message may include transmitting the third message if the database indicates that the first and second terminals are paired.

Further embodiments provide wireless communications systems configured to perform such methods.

Additional embodiments provide methods of operating a wireless communications terminal. The methods include receiving a message including an anonymous discovery pilot identification code from a wireless communications system and transmitting a discovery pilot signal including the discovery pilot identification code. Receipt of the message including the discovery pilot identification code may be preceded by transmitting a message to the wireless communications system requesting permission to transmit a discovery pilot signal. Transmission of the message to the wireless communications system requesting permission to transmit the discovery pilot signal may be preceded by identifying a pairing relationship with another terminal to the wireless communications system. Identifying the pairing relationship may include transmitting a message identifying the pairing relationship to the wireless communications system.

Further embodiments provide wireless communications terminals configured to perform such methods.

Still further embodiments of the inventive subject matter provide methods of operating a wireless communications terminal. The methods include receiving at least one discovery pilot signal, recovering at least one anonymous discovery pilot identification code from the at least one received discovery pilot signal, transmitting a message to a wireless communications system identifying the recovered at least one discovery pilot identification code and receiving a message identifying another terminal associated with the at least one discovery pilot identification code from the wireless communications system. Receipt of the at least one discovery pilot signal may be preceded by identifying a pairing relationship with the other terminal to the wireless communications system.

Further embodiments provide wireless communications terminals configured to perform such methods.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features of the inventive subject matter will be more readily understood from the following detailed description of specific embodiments thereof when read in conjunction with the accompanying drawings, in which:

FIG. **1** is a schematic diagram illustrating a wireless communications system according to some embodiments;

FIG. **2** is a diagram illustrating messaging in the wireless communications system of FIG. **2**; and

FIG. **3** is a schematic diagram illustrating a wireless communications terminal according to some embodiments.

DETAILED DESCRIPTION

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit the invention to the particular forms disclosed, but on the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the claims. Like reference numbers signify like elements throughout the description of the figures.

As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless expressly stated otherwise. It should be further understood that the terms "comprises" and/or "comprising" when used in this specification is taken to specify the presence of stated features, integers, steps, operations, elements, and/or components, but does not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. Furthermore, "connected" or "coupled" as used herein may include wirelessly connected or coupled. As used

herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and this specification and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

The inventive subject matter may be embodied as methods, electronic devices, and/or computer program products. Accordingly, the inventive subject matter may be embodied in hardware and/or in software (including firmware, resident software, micro-code, etc.). Furthermore, the inventive subject matter may take the form of a computer program product comprising a computer-usable or computer-readable storage medium having computer-usable or computer-readable program code embodied in the medium for use by or in connection with an instruction execution system. In the context of this document, a computer-usable or computer-readable medium may be any medium that can contain or store the program for use by or in connection with the instruction execution system, apparatus, or device.

The computer-usable or computer-readable medium may be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. More specific examples (a nonexhaustive list) of the computer-readable medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, and a compact disc read-only memory (CD-ROM). Note that the computer-usable or computer-readable medium could even be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via, for instance, optical scanning of the paper or other medium, then compiled, interpreted, or otherwise processed in a suitable manner, if necessary, and then stored in a computer memory.

As used herein, a "terminal" may include a satellite or cellular radiotelephone with or without a multi-line display; a Personal Communications System (PCS) terminal that may combine a cellular radiotelephone with data processing, facsimile and data communications capabilities; a PDA that can include a radiotelephone, pager, Internet/intranet access, Web browser, organizer, calendar and/or a global positioning system (GPS) receiver; and a conventional laptop and/or palmtop receiver or other appliance that includes a radiotelephone transceiver. Terminals may also be referred to as "pervasive computing" devices.

Some embodiments of the inventive subject matter stem from a realization that a wireless communications network, e.g., a cellular network, can be used to support an anonymous device discovery process that may be used by paired terminals to locate one another without requiring position determination or exchange of position information. Rather, in some embodiments, a terminal in communication with the wireless network may be allowed to transmit its own temporarily assigned tracking signal. The tracking signal may use a network-assigned discovery pilot identification code that does not reveal the identity or location of the transmitting terminal and may be transmitted, for example, using a reserved portion of the radio resource used by the network. Other terminals within proximity of the transmitting terminal may receive and decode the tracking signal to recover the network-assigned discovery pilot identification code and, in response to providing the recovered discovery pilot identification code to the network, be informed of the presence of the other terminal.

FIG. **1** illustrates a wireless communications system **100** according to some embodiments. The system **100** includes one or more wireless network access nodes, here shown as wireless base stations **110***a*, **120***b*. It will be appreciated that the base stations **110***a*, **110***b* may include, for example, conventional cellular network base stations and/or access points or other devices that provide similar functionality in wide and/or local area wireless networks. The base stations **110***a*, **110***b* may serve respective overlapping or non-overlapping geographical areas and/or the same or different populations of users or subscribers. The base stations **110***a*, **110***b* may utilize the same or different radio resources. For example, the base stations **110***a*, **110***b* may serve respective geographical cells of the same cellular communications network using a common radio resource and/or a common protocol, or may be stations of different networks that utilize different radio resources under different protocols.

The base stations **110***a*, **110***b* are coupled to other network infrastructure **120**. The network infrastructure **120** may comprise the core network of a given cellular system to which the base stations **110***a*, **110***b* belong (e.g., switching centers and other backbone network components that support the base stations **110***a*, **110***b*) or, in case in which the base stations **110***a*, **110***b* are from different networks, may comprise a combination of components of multiple networks. The network infrastructure **120** is configured to interoperate with a pairing database **130**, which may support a pairing discovery functionality that may be provided by the network infrastructure **120** as described in detail below. The pairing database **130** may be maintained by an operator of the system **100** and/or may be an external database accessible via the Internet.

Wireless terminals **10***a*, **10***b* are configured to communicate with at least one of the base stations **110***a*, **110***b*. As further shown in dotted line, the wireless terminals **10***a*, **10***b* are in a paired relationship. The pairing may take various forms and can be achieved in many different ways. For example, the terminals **10***a*, **10***b* may be paired using NFC, Bluetooth or other short-distance communications and/or by longer distance communications via the Internet. The pairing may be for any of a variety of purposes, such as for conducting commercial services or facilitating interest group participation. The pairing may or may not entail direct communications between the terminals **10***a*, **10***b*. Although FIG. **1** illustrate the terminals **10***a*, **10***b* in communication with respective base stations **110***a*, **110***b*, it will be appreciated that communications of the terminals **10***a*, **10***b* to support discovery processes according to various embodiments may utilize a single base station or access node, or may utilize multiple base stations or access nodes.

FIG. **2** illustrates message flow for a discovery process according to some embodiments. Referring to FIG. **2** with continuing reference to FIG. **1**, the first terminal **10***a* transmits a message to the wireless communications system **100** requesting permission to transmit a discovery pilot signal. This request message may be received, for example, by the first base station **110***a*. In response, the system **100** transmits a message to the first terminal **10***a* that grants the request and includes a discovery pilot identification code for transmission of the discovery pilot signal. This message may also include other control information, such as a transmit power level the

first terminal **10***a* should use for its discovery pilot signal. Using the discovery pilot identification code and associated control information, the first terminal **10***a* transmits its discovery pilot signal.

The second terminal **10***b* receives the transmitted discovery pilot signal and extracts the discovery pilot identification code. After extracting the discovery pilot identification code, the second terminal **10***b* transmits a message identifying the recovered discovery pilot identification code to the system **100**. In addition, the second terminal **10***b* may include other discovery pilot identification codes the second terminal **10***b* may have extracted from other received discovery pilot signals. The system **100** receives the message identifying the discovery pilot identification code for the first terminal **10***a*, and matches up the identified discovery pilot identification code with a non-anonymous terminal ID for the terminal **10***a* by, for example, referring to the pairing database **130**. The system **100** then transmits a message to the second terminal **10***b* including the terminal ID for the first terminal **10***a*, thus informing the second terminal **10***b* of the proximity of the first terminal **10***a*. The second terminal **10***a* may use this information to perform operations relating to the paired relationship between the first terminal **10***a* and the second terminal **10***b*, such as direct or indirect communications between the first terminal **10***a* and the second terminal **10***b*.

Before the operations described above may be performed, a pairing relationship is established between the first terminal **10***a* and the second terminal **10***b* and communicated to the wireless communication system **100** to, for example, create appropriate entries in the pairing database **130**. For example, as shown, after a pairing relationship is established, the first terminal **10***a* and the second terminal **10***b* may each send messages identifying the pairing relationship, which the system **100** may use to populate the pairing database **130**.

In some embodiments, the information used for pairing may include an international mobile equipment identity (IMEI) unique to the device and/or a caller ID (telephone number) associated with a particular subscription. The pairing database **130** may establish correspondence between the IMEI and/or caller ID and a unique discovery pilot identification code as shown in Table 1:

TABLE 1

Terminal ID	Paired Terminal ID	Discovery Pilot ID code
Terminal A IMEI	Terminal B IMEI	A
Terminal B IMEI	Terminal A IMEI	B
...	...	...

The discovery pilot identification codes may be assigned such that different terminals in the same area do not use the same code, but the discovery pilot identification codes are not required to be unique for all terminals in a system and can generally be reused to the extent that there is no undue likelihood of conflicts.

The radio resource available for any mobile communication system can be described as a certain amount of frequency band that can be utilized with a certain amount of total transmitted energy. Radio resource is often divided in time (e.g., as in time division multiple access (TDMA)) and/or parts of the frequency (e.g., as in frequency division multiple access (FDMA)), in order to distinguish different terminal and base station signals. In addition, codes can be applied to signal to achieve code division multiplexing (CDMA), wherein signals overlapping in time and frequency can be distinguished.

According to some embodiments of the inventive subject matter, terminals may transmit discovery pilot signals using overlapping time and frequency during defined transmission windows, such that a portion of the radio resource may be reserved for transmission of such discovery pilot signals. The techniques used for discovery pilot signal transmission may be similar, for example, to those used in the LTE standard for cell pilot signals ("reference signals"). To distinguish among discovery pilot signals, in some embodiments, terminals may encode their discovery pilot signals with the discovery pilot identification codes received from the system using a CDMA type spread spectrum coding.

When another terminal (e.g., terminal **10***b* in FIG. **1**) conducts a search (automatically and/or by user command) for other terminals within proximity, it will monitor the discovery pilot signal time/frequency slots, much like it monitors cell pilot signal time/frequency slots. The allocated discovery pilot radio resource can be predefined by a standard and/or may be defined in a static or dynamic manner by the wireless communication system using system control channel signaling.

For each detected discovery pilot signal received, the receiving terminal may identify the discovery pilot identification code in a manner similar to that used by terminals in a cell search procedure. The discovered discovery pilot identification codes may be kept anonymous, thus providing the ability to prevent another agent from tracing or tracking terminal identity. In order for the terminal receiving discovery pilot identification codes to identify whether one or more of the discovered codes (and thereby terminals) are paired or otherwise associated with the receiving terminal, the receiving terminal sends the found discovery pilot identification codes to the wireless communication system, which analyzes the discovery data base and responds with an appropriate terminal and/or subscriber ID. This approach can provide a desirable level of security.

FIG. **3** illustrates a wireless terminal **300** that may support the operations described above. As shown, the wireless terminal **300** includes a processor **305** (e.g., one more microprocessor and/or signal processor chips) configured to interoperate with a memory **310**, which may be used to store executable code and data. The processor **305** may also be coupled to various communications circuits that can be used to support the functions described above. For example, the processor **305** may be coupled to a cellular radio communications circuit **315** that provides connectivity to cellular networks, a wireless local area network (WLAN) communications circuit **320** that supports local wireless communications (WiFi, Bluetooth and the like) and a near-field communications (NFC) circuit **325**, which supports close range communications with other terminals or devices. The terminal **300** may also include user interface components that interoperate with the processor **305**, such as a display **330**, a keypad **335**, a microphone **340**, a speaker **345**, and a camera **350**.

The processor **305** and memory **310** may be configured to store and execute computer code that causes the wireless terminal **300** to perform the discovery pilot signal transmission, reception and message processing operations described above with reference to FIGS. **1** and **2**. For example, the memory **310** may include executable code and data **312** configured to support pairing operations, along with executable code and data **314** configured to support discovery pilot signal encoding, transmission, reception, decoding and associated communications operations. As discussed above, these communications may involve cellular, WLAN and/or near-field communications.

Some embodiments of the inventive subject matter may be implemented in wireless communications standards, such as that defined by the 3GPP Specification, which covers GSM (including GPRS and EDGE), W-CDMA and LTE (including LTE-Advanced) specifications (the 3GPP specification is available at www.3GPP.org). For example, some embodiments may be specified by changes and/or additions to physical layer aspects defined at 3GPP TS 36.211, 36.212 and/or 36.213 and/or radio resource control aspects defined at 3GPP TS 36.331. It will be appreciated that these sections are cited as an example, and that embodiments of the inventive subject matter may be implemented in 3GPP or other communications specifications in a number of different ways.

Many variations and modifications can be made to the exemplary embodiments without substantially departing from the principles of the inventive subject matter. All such variations and modifications are intended to be included herein within the scope of the inventive subject matter, as set forth in the following claims.

That which is claimed:

1. A method of operating a wireless communications system, the method comprising:

receiving, at the wireless communications system, a request message from a first terminal requesting permission to transmit a discovery pilot signal to a second terminal;

transmitting, from the wireless communications system, a first message including an anonymous discovery pilot identification code to the first terminal;

receiving, at the wireless communications system, a second message from the second terminal;

determining whether the second message identifies the anonymous discovery pilot identification code by searching a database responsive to the second message identifying the anonymous discovery pilot identification code to determine whether the second terminal is paired with the first terminal; and

transmitting, from the wireless communications system, a third message identifying the first terminal to the second terminal if the database indicates that the first and second terminals are paired.

2. The method of claim **1**, wherein transmitting, from the wireless communications system, the first message is preceded by receiving, at the wireless communications system, at least one message identifying a relationship between the first and second terminals.

3. The method of claim **2**, wherein receiving, at the wireless communications system, at least one message identifying a relationship between the first and second terminals comprises receiving respective messages from the first and second terminals.

4. The method of claim **1**, further comprising reserving a portion of a radio resource for transmission of pilot discovery signals by terminals.

5. A wireless communications system, the wireless communications system comprising:

a base station configured to provide communications over a wireless channel with a wireless communications terminal further comprising a processor coupled to the base station, wherein the processor is configured to:

receive a message from a first terminal requesting permission to transmit a discovery pilot signal;

transmit a first message including an anonymous discovery pilot identification code to the first terminal;

receive a second message from a second terminal;

determine whether the second message identifies the anonymous discovery pilot identification code by searching a database responsive to the second message identifying the anonymous discovery pilot identification code to determine whether the second terminal is paired with the first terminal; and

transmit, from the wireless communications system, a third message identifying the first terminal to the second terminal if the database indicates that the first and second terminals are paired.

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